MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

EPM4086 – DIGITAL CONTROL SYSTEMS

(RE)

29 MAY 2017
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages including cover page with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. Table of Transform pairs has been included in Appendix.

Question 1

(a) The following signals are sampled by an ideal sampler with sampling period T. Determine the pulse transform $Y^*(s)$

(i) $y(t) = \cos \omega t \,;\ t \geq 0$ [9 marks]

(ii) $y(t) = e^{-5t} \sin 4t \,;\ t \geq 0$ [6 marks]

(b) Find the inverse z-transform of following function using partial-fraction expansion.

$$F(z) = \frac{4z}{(z-1).(z^2 - 0.1z - 0.2)}$$

[8 marks]

(c) Find the final values of $x(k)$ if its z-transform is given as:

$$X(z) = \frac{10z(z-0.2).(z-0.5)}{(z-1).(z^2 - 0.6z + 0.4)}$$

[2 marks]

Continued...

Question 2

(a) Determine the discrete-time output $C(z)$ of the closed-loop control system as shown in Fig Q2(a).

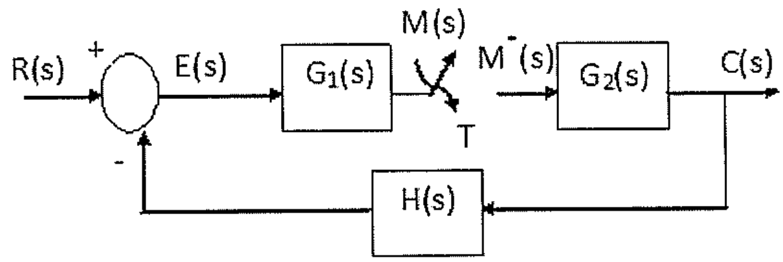

Fig Q2(a)

(Note: $R(s)$ is system input, $C(s)$ is system output, $G_1(s)$, $G_2(s)$, $H(s)$ are three continuous-time transfer functions of the respective blocks, $M(s)$ and $M^*(s)$ are respectively the sampler input and output, T is the sampling period).

[15 marks]

(b) The transfer function of a discrete control system is given as

$$G(z) = \frac{z(z+0.3)}{(z+0.5)*(z-0.4)}$$

(i) Determine the poles and zeros of the system and locate them in a z-plane.

[7 marks]

(ii) Determine whether the system is stable or not? Justify.

[3 marks]

Continued...

Question 3

(a) The characteristic equation of a linear discrete-time control system is given as

$$F(z) = z^3 + 5z^2 - z + 5K = 0$$

Determine the values of K for the system to be stable using Routh Hurwitz criteria. [10 marks]

(b) The sampled data control system as shown in Fig Q3 (b),

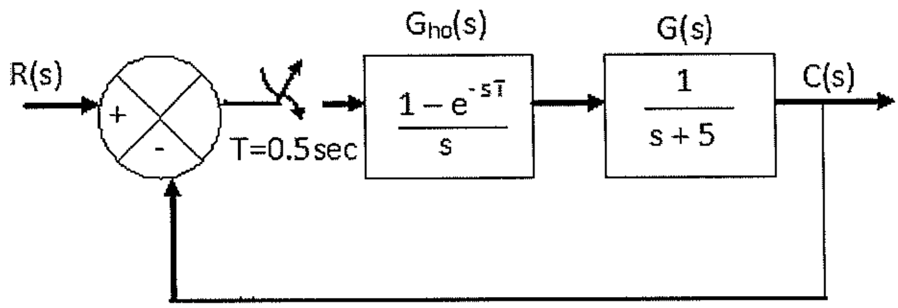

Fig Q3 (b)

Determine the following

(i) Closed loop transfer function of the system [10 marks]

(ii) Stability of the system [1 mark]

(iii) Position error constant, Velocity error constant and Acceleration error constant [3 marks]

(iv) Steady state error when the input applied is unit step. [1 mark]

Continued...

Question 4

(a) The state space model of a linear discrete-time system is given by

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -0.4 & -1.3 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} 0.8 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

where $x_1(k)$ and $x_2(k)$ are state variables, $u(k)$ is the system input and $y(k)$ is the system output. Determine the complete Controllability and Observability of the system.

[13 marks]

(b) A linear time-invariant system is characterized by homogeneous state equation

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

Determine the state transition matrix $\varphi(k)$.

[12 marks]

Continued...

Appendix

TABLE OF Z-TRANSFORM PAIRS

(e = Euler number)

Time function $f(t); t > 0$	**Laplace Transform** $F(s)$	**Z-transform** $F(z), T =$ **Sampling time**
$u_s(t)$	$1/s$	$z/(z-1)$
t	$1/s^2$	$Tz/(z-1)^2$
t^2	$2/s^3$	$T^2 z(z+1)/(z-1)^3$
ε^{-at}	$1/(s+a)$	$z/(z-\varepsilon^{-aT})$
$1-\varepsilon^{-at}$	$a/\{s(s+a)\}$	$z(1-\varepsilon^{-aT})/\{(z-1)(z-\varepsilon^{-aT})\}$
$t\varepsilon^{-at}$	$1/(s+a)^2$	$Tz\varepsilon^{-aT}/(z-\varepsilon^{-aT})^2$
$\sin at$	$a/(s^2+a^2)$	$z\sin aT/(z^2-2z\cos aT+1)$
$\cos at$	$s/(s^2+a^2)$	$z(z-\cos aT)/(z^2-2z\cos aT+1)$
$\varepsilon^{-at}\sin bt$	$b/\{(s+a)^2+b^2\}$	$z\varepsilon^{-aT}\sin bT/(z^2-2z\varepsilon^{-aT}\cos bT+\varepsilon^{-2aT})$
$\varepsilon^{-at}\cos bt$	$(s+a)/\{(s+a)^2+b^2\}$	$(z^2-z\varepsilon^{-aT}\cos bT)/(z^2-2z\varepsilon^{-aT}\cos bT+\varepsilon^{-2aT})$

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